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"ANALYSIS OF THE EFFECTIVENESS OF BIOPREPARATIONS DERIVED FROM MICROORGANISMS IN THE CULTIVATION OF ORNAMENTAL PLANTS IN SCHOOL BIOLOGY LESSONS."

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ABSTRACT

The growing interest in environmentally friendly and sustainable agricultural practices has increased the relevance of biopreparations derived from microorganisms in plant cultivation. This article analyzes the effectiveness of microbial-based biopreparations in the cultivation of ornamental plants within the framework of school biology lessons. The study aims to evaluate not only the biological impact of these biopreparations on plant growth, development, and resistance to diseases, but also their pedagogical value in enhancing students' practical skills and ecological awareness. The research is based on experimental observations conducted during biology classes, where ornamental plants were cultivated using selected microbial biopreparations, including biofertilizers and biostimulants, and compared with traditionally cultivated plants. Quantitative and qualitative indicators such as germination rate, growth dynamics, leaf coloration, flowering intensity, and overall plant vitality were systematically analyzed. The results demonstrate that the use of microorganism-derived biopreparations significantly improves plant growth parameters and stress tolerance, while reducing the need for chemical fertilizers. Moreover, integrating this topic into school biology lessons promotes students' understanding of microbiological processes, sustainable agriculture, and the role of beneficial microorganisms in ecosystems. The study concludes that microbial biopreparations are not only effective tools for ornamental plant cultivation but also valuable educational resources for developing scientific thinking, environmental responsibility, and practical competence among school students.

Keywords: biopreparations, beneficial microorganisms, ornamental plants, school biology education, plant growth stimulation, biofertilizers, sustainable agriculture, microbial inoculants, environmental education, experimental teaching methods.

INTRODUCTION

In recent years, the rapid development of biological sciences and increasing environmental challenges have intensified the search for sustainable and eco-friendly approaches in plant cultivation. One of the most promising directions in this field is the use of biopreparations derived from beneficial microorganisms. These biological products, which include biofertilizers, biostimulants, and microbial inoculants, play a significant role in enhancing plant growth, improving soil fertility, and reducing dependence on chemical fertilizers. Their application is especially relevant in the cultivation of ornamental plants, where plant vitality, aesthetic quality, and environmental safety are of primary importance.

Ornamental plants occupy a special place in school biology education, as they are widely used in practical lessons, laboratory work, and extracurricular activities. Through the cultivation of ornamental plants, students not only acquire basic botanical knowledge but also develop practical skills, ecological awareness, and an understanding of sustainable agricultural practices. Integrating modern biotechnological approaches, such as microbial biopreparations, into school biology lessons allows educators to bridge theoretical knowledge with real-world biological processes.

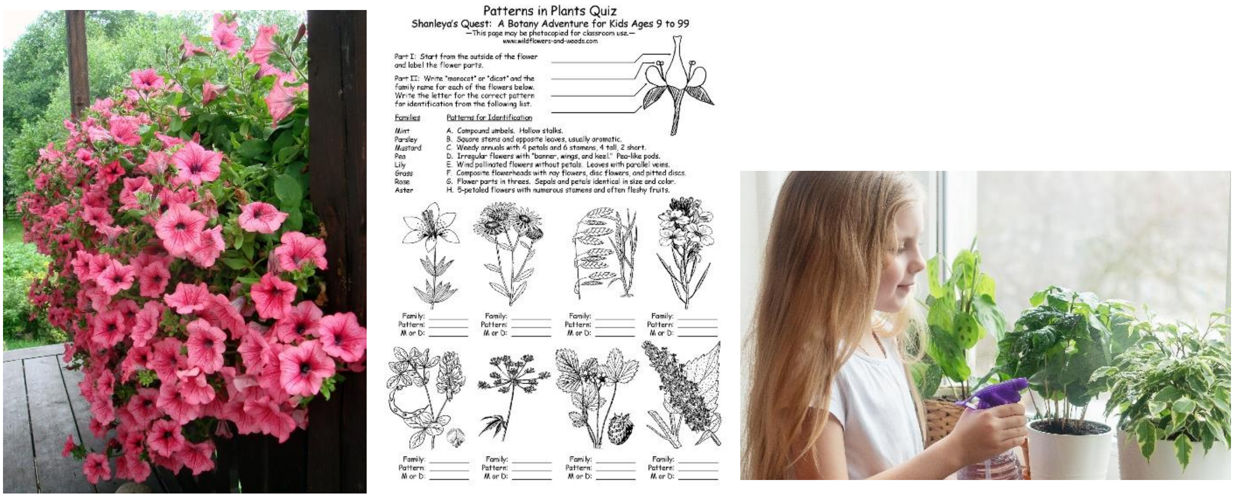

Figure 1. Cultivation of ornamental plants as part of school biology lessons.

Microorganisms used in biopreparations, including nitrogen-fixing bacteria, phosphate-solubilizing microorganisms, and plant growth-promoting rhizobacteria, contribute to improved nutrient uptake, enhanced resistance to diseases, and better adaptation of plants to environmental stress factors. Numerous scientific studies confirm the effectiveness of these microorganisms in agricultural systems; however, their application in educational settings, particularly in school biology lessons, remains insufficiently explored. This creates a need for systematic analysis of both their biological effectiveness and their pedagogical value.

The relevance of this study lies in the intersection of biology education and sustainable plant cultivation. By analyzing the effectiveness of microorganism-derived biopreparations in growing ornamental plants during school biology lessons, it becomes possible to evaluate not only plant growth indicators but also the educational outcomes associated with hands-on learning. Such an approach contributes to the formation of students' scientific thinking, environmental responsibility, and interest in modern biological technologies.

The aim of this research is to analyze the effectiveness of biopreparations derived from microorganisms in the cultivation of ornamental plants within the framework of school biology lessons. The study seeks to assess their impact on plant growth and development, compare the results with traditional cultivation methods, and determine their educational significance in improving students' understanding of microbiological processes and sustainable agriculture.

MATERIALS AND METHODS

The research was conducted within the framework of school biology lessons during the academic year and was designed to evaluate the effectiveness of biopreparations derived from microorganisms in the cultivation of ornamental plants. The study combined experimental, observational, and comparative research methods, ensuring both scientific reliability and pedagogical relevance. Practical activities were integrated into regular biology classes, allowing students to actively participate in the experimental process under teacher supervision.

The experimental material consisted of commonly cultivated ornamental plants suitable for school conditions, including fast-growing and visually expressive species. These plants were selected due to their adaptability to indoor and outdoor environments, clear growth indicators, and relevance for educational purposes. Seeds and seedlings of uniform quality were used to ensure consistency across experimental groups.

Microbial biopreparations used in the study were selected based on their widespread application in plant cultivation and their proven biological activity. These biopreparations contained beneficial microorganisms such as nitrogen-fixing bacteria, phosphate-solubilizing bacteria, and plant growth-promoting rhizobacteria. The preparations were applied according to manufacturer recommendations, with strict adherence to dosage, application frequency, and safety guidelines. All treatments were conducted in compliance with basic biological safety and hygiene standards appropriate for school laboratory conditions.

The experimental design included two main groups: an experimental group and a control group. Plants in the experimental group were cultivated using microbial biopreparations, while plants in the control group were grown under identical environmental conditions without the application of biopreparations, relying on traditional cultivation methods. Both groups received equal amounts of water, light, and care to eliminate external influencing factors. Environmental conditions such as temperature, humidity, and light exposure were monitored regularly to maintain uniformity.

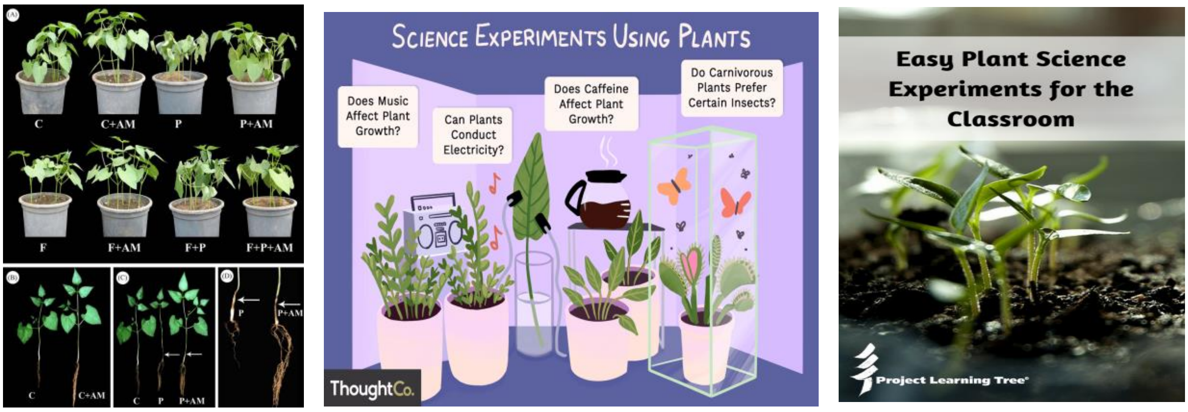

Figure 2. Experimental and control groups used in the cultivation of ornamental plants.

Data collection focused on both quantitative and qualitative indicators of plant development. Quantitative parameters included germination rate, plant height, number of leaves, growth rate, and duration of flowering. Qualitative indicators involved leaf color intensity, overall plant vitality, resistance to visible diseases, and aesthetic appearance. Observations were recorded systematically throughout the growth period using measurement tools and visual assessment scales adapted for educational research.

In addition to biological indicators, pedagogical observations were carried out to assess the educational impact of integrating biopreparations into biology lessons. Students' engagement levels, interest in microbiological processes, and ability to explain the role of microorganisms in plant growth were evaluated through classroom discussions, short written reflections, and teacher observations. This approach allowed the study to assess not only biological effectiveness but also the didactic value of the experimental activities.

The collected data were analyzed using comparative and descriptive statistical methods. Mean values and growth trends were compared between the experimental and control groups to determine the effectiveness of microbial biopreparations. The results were interpreted in relation to both plant development outcomes and educational objectives, providing a comprehensive assessment of the research problem.

RESULTS

The results of the study revealed a clear positive effect of biopreparations derived from microorganisms on the growth and development of ornamental plants cultivated during school biology lessons. Comparative analysis between the experimental and control groups demonstrated

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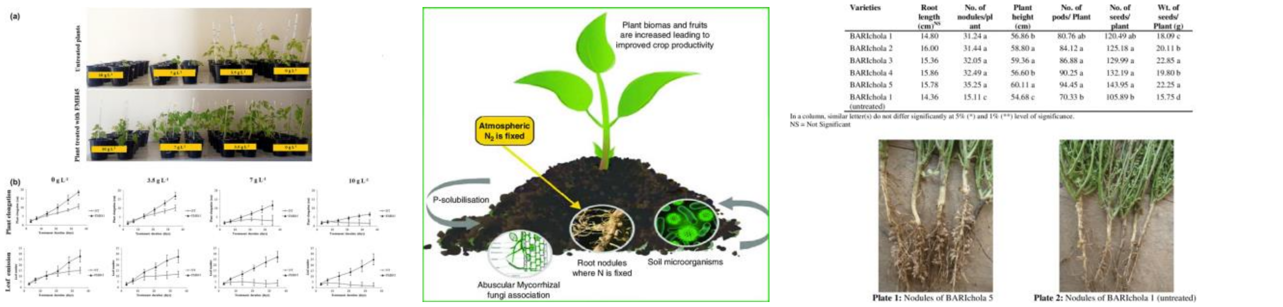
significant differences across several key biological indicators, confirming the effectiveness of microbial-based treatments under educational conditions.

Seed germination in the experimental group showed a higher and more uniform rate compared to the control group. Seeds treated with microbial biopreparations germinated earlier and exhibited stronger initial growth, resulting in healthier seedlings. This early developmental advantage contributed to improved plant establishment and reduced losses during the initial growth stages. In contrast, the control group displayed slower and less consistent germination, with noticeable variability among individual plants.

Growth dynamics analysis indicated that plants in the experimental group achieved greater average height and a higher number of leaves throughout the observation period. The enhanced vegetative growth was particularly evident during the active growth phase, where treated plants demonstrated accelerated development and more robust stem structure. Leaf morphology in the experimental group was characterized by increased leaf size and deeper green coloration, indicating improved chlorophyll content and nutrient uptake.

Flowering characteristics also differed notably between the two groups. Ornamental plants cultivated with the application of microbial biopreparations entered the flowering stage earlier and maintained longer flowering periods. The intensity and uniformity of flowering were higher in the experimental group, contributing to superior aesthetic quality. In comparison, plants in the control group showed delayed flowering and less abundant blooms, which reduced their decorative value.



Varieties	Root length (cm)^{NS}	No. of nodules/plant	Plant height (cm)	No. of pods/ Plant	No. of seeds/ plant	Wt. of seeds/ Plant (g)
BARIchola 1	14.80	31.24 a	56.86 b	80.76 ab	120.49 ab	18.09 c
BARIchola 2	16.00	31.44 a	58.80 a	84.12 a	125.18 a	20.11 b
BARIchola 3	15.36	32.05 a	59.36 a	86.88 a	129.99 a	22.85 a
BARIchola 4	15.86	32.49 a	56.60 b	90.25 a	132.19 a	19.80 b
BARIchola 5	15.78	35.25 a	60.11 a	94.45 a	143.95 a	22.25 a
BARIchola 1 (untreated)	14.36	15.11 c	54.68 c	70.33 b	105.89 b	15.75 d

In a column, similar letter(s) do not differ significantly at 5% (*) and 1% (**) level of significance.
NS = Not Significant

Figure 3. Comparison of growth parameters between biopreparation-treated plants and untreated plants

Plant health and resistance indicators further supported the effectiveness of microorganism-derived biopreparations. Treated plants exhibited greater resistance to common stress factors, such as temporary water deficiency and minor temperature fluctuations. Visible symptoms of plant diseases and physiological disorders were less frequent in the experimental group, whereas the control group showed a higher occurrence of leaf yellowing and growth retardation.

In addition to biological outcomes, the integration of microbial biopreparations into biology lessons had a positive educational impact. Students demonstrated increased interest and engagement during practical activities, particularly when observing visible differences between treated and untreated plants. Classroom discussions and written reflections indicated an improved understanding of the role of microorganisms in plant nutrition and ecosystem functioning. Students were able to explain the biological mechanisms underlying plant growth stimulation more accurately, linking theoretical knowledge with experimental observations.

Overall, the results confirm that biopreparations derived from microorganisms significantly enhance ornamental plant growth, vitality, and decorative qualities under school conditions. At the same time, their use contributes to more effective biology education by promoting experiential learning and ecological awareness.

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DISCUSSION

The findings of this study confirm that biopreparations derived from microorganisms play a significant role in improving the growth and development of ornamental plants cultivated in school biology lessons. The observed improvements in germination rate, vegetative growth, flowering intensity, and plant health are consistent with existing scientific research on the positive effects of beneficial microorganisms in plant cultivation. These results support the hypothesis that microbial biopreparations enhance plant physiological processes by improving nutrient availability and stimulating natural growth mechanisms.

One of the key explanations for the improved growth performance in the experimental group lies in the biological activity of the microorganisms present in the biopreparations. Nitrogen-fixing bacteria contribute to increased nitrogen availability, while phosphate-solubilizing microorganisms improve phosphorus uptake, both of which are essential for plant development. In addition, plant growth-promoting rhizobacteria stimulate root development and enhance the synthesis of phytohormones, leading to stronger and more resilient plants. These mechanisms likely account for the accelerated growth dynamics and improved leaf coloration observed in treated plants.

The earlier onset and prolonged duration of flowering in the experimental group can be interpreted as a result of balanced nutrient absorption and enhanced metabolic activity. Ornamental plants are particularly sensitive to nutrient deficiencies, which directly affect their aesthetic qualities. The use of microbial biopreparations appears to create more favorable conditions for continuous and uniform flowering, thereby increasing the decorative value of the plants. This finding is especially relevant for educational settings, where visual outcomes play an important role in maintaining student interest and motivation.

From an educational perspective, the integration of biopreparations into school biology lessons proved to be highly effective. The hands-on experimental approach allowed students to actively observe biological processes rather than passively receive information. This experiential learning model facilitated deeper understanding of microbiological concepts and reinforced the connection between theoretical knowledge and real-life applications. Students' improved ability to explain the role of microorganisms in plant growth indicates the development of scientific thinking and analytical skills.

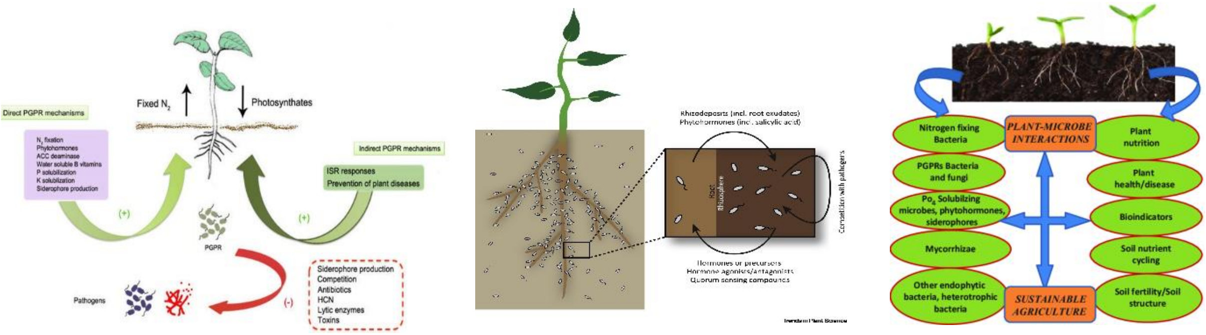

Figure 4. Interaction between beneficial microorganisms and plant root systems.

The results also highlight the environmental significance of using biopreparations in educational practice. Reducing reliance on chemical fertilizers aligns with the principles of sustainable development and environmental protection. Introducing students to eco-friendly cultivation methods at an early stage fosters ecological responsibility and awareness of sustainable agricultural practices. In this context, school biology lessons serve not only as a platform for knowledge acquisition but also as a means of shaping environmentally conscious attitudes.

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Despite the positive outcomes, the study has certain limitations. The experimental period was limited to a single academic year, and the range of ornamental plant species was restricted. Future research could expand the duration of observations, include a wider variety of plant species, and apply more advanced statistical analysis methods to further validate the findings. Nevertheless, the results provide a strong foundation for the broader application of microbial biopreparations in biology education.

CONCLUSION

This study demonstrates that biopreparations derived from microorganisms are highly effective in the cultivation of ornamental plants within the context of school biology lessons. The experimental results clearly indicate that the application of microbial biopreparations positively influences key growth parameters, including germination rate, vegetative development, flowering intensity, and overall plant vitality. Compared to traditional cultivation methods, plants treated with biopreparations showed stronger growth performance, improved resistance to stress factors, and enhanced aesthetic qualities.

Figure 5. Educational and ecological benefits of using microbial biopreparations.

Beyond their biological effectiveness, microbial biopreparations proved to be valuable educational tools. Their integration into biology lessons created opportunities for experiential learning, enabling students to observe and analyze real biological processes. This approach contributed to a deeper understanding of microbiology, plant physiology, and ecological interactions, while also fostering scientific thinking and practical skills. Students became more engaged in the learning process and demonstrated greater awareness of the role of beneficial microorganisms in sustainable plant cultivation.

The findings highlight the importance of incorporating modern biotechnological approaches into school biology education. The use of environmentally friendly biopreparations supports sustainable development principles by reducing dependence on chemical fertilizers and promoting ecological responsibility. Introducing such practices at the school level helps shape students' attitudes toward environmental protection and sustainable agriculture.

In conclusion, biopreparations derived from microorganisms can be recommended for widespread use in school biology lessons focused on ornamental plant cultivation. Their dual benefits—enhancing plant growth and improving educational outcomes—make them an effective and relevant component of modern biology education. Future research may further expand on these findings by exploring a broader range of plant species, longer observation periods, and advanced analytical methods to strengthen the scientific and pedagogical basis of this approach.

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